AD-A192 298 DEFECTS IN HIGH-MOBILITY SEMICONDUCTOR SYSTEMS(U) LUND UNIV (SWEDEN) DEPT OF SOLID STATE PHYSICS H GRIMMEISS 23 DEC 87 DAJA45-87-C-0052 1/1

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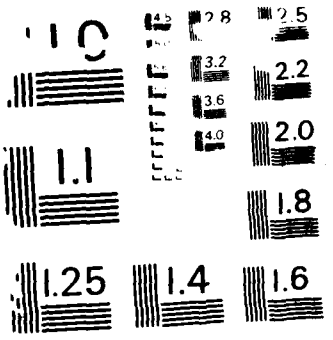
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Second Interim Report

23 Dec 1987

DEFECTS IN HIGH-MOBILITY SEMICONDUCTOR SYSTEMS

Contract: DAJA45-87-C-0052 R&D Proposal: 5919-PH-01

Work under subject contract was continued in the period 23 Oct thru 23 Dec 1987 on (a) extensive electrical examination of the P_b center on silicon surfaces; (b) preliminary electrical investigation of the new metastable (GaAs) defect which competes with the EL-2 center; (c) initial EPR measurements on a high T_c ceramic superconductor; (d) related conceptual studies and tests.

(a) The photocapacitance system described in the First Interim Report was applied to an extensive study of the P_b center on oxidized Si surfaces. This center is the most important defect in integrated circuit technology, and serves as an ideal reference for study of other less-well characterized defects. Further, the photocapacitance approach in itself provides extensive new information on P_b which is important to IC technology. The results on P_b also contribute to development of a rigorous and comprehensive physico-chemical model for all point defects in semiconductors and their associated insulators and interfaces.

In p-type Si at 80 K, the energy threshold for optical excitation of an electron from the valence band into the empty P_b center is found to be 0.45 eV; in n-type Si, the threshold for excitation of an electron from the doubly occupied p_b center into

the conduction band is about 0.43eV. Energies for the corresponding thermal excitations are 0.33 eV and 0.35 eV. In n-type Si, the threshold for excitation of the second P_b electron into the conduction band is about 0.8 eV; in p-type Si, the analogous excitation of a second electron from the valence band into the singly occupied P_b center is not observed. At 300 K, low-frequency capacitance-voltage analysis and field-controlled EPR show the energy level of the singly occupied P_b center at $E_V+0.3$ eV and the doubly occupied P_b center at $E_C-0.3$ eV. The difference between thermal equilibrium and optical results suggests a configurational change in the P_b center with electron occupancy. This latter result is in accord with molecular orbital calculations. In total, the findings constitute the most comprehensive total model of any integrated circuit defect ever achieved.

(b) Preliminary examination of a new metastable defect in GaAs was initiated. The analysis of this trap yielded results in excellent concert with the well-established models developed for numerous other bulk defects. The pattern of results is also in concord with the P_b study, thus strongly reinforcing the validity of the work described above. With instrumentation and approach thus verified, the metastable center will be pursued in depth in the next reporting period.

(c) A number of EPR observations on the high-Tc superconductor ceramic $YBa_2Cu_3O_{7-}$ were performed. Two new features were examined for the first time: a nuclear hyperfine structure, and passage through the critical temperature transition. Note that

this investigation was not envisioned in the original proposal, which was conceived before the general dissemination of the high-T_c breakthrough. However, these very exciting materials have extensive possibilities for high-speed electronic devices, and it was deemed urgent to initiate a preliminary study. This investigation will be extended in the next period.

(d) In addition to the specific research described above, several other important projects are in conceptual and early test stages:

1. Optical transitions of P_b centers, so far not observed by EPR: The reason for this anomaly is not at all understood. It may portend some very novel and significant new defect physics of wide applicability.

2. Spin-dependent recombination phenomena were considered as a possibility to link EPR and photocapacitance data in case of failure of optical stimulation, as seemingly is the case for P_b.

3. A number of special sample fabrication plans were set into implementation at local MBE facilities (GaAs) and at UCLA (Si and Ge) for future studies on semiconductor defects.

Hermann Grimmeiss
Principal Investigator
Department of Solid State Physics
University of Lund

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